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Short note

Low-cost conversion of the Polaroid MD-4 land camera to a digital gel documentation system

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Abstract

A simple, inexpensive design is presented for the rapid conversion of the popular MD-4 Polaroid land camera to a high quality digital gel documentation system. Images of ethidium bromide stained DNA gels captured using the digital system were compared to images captured on Polaroid instant film. Resolution and sensitivity were enhanced using the digital system. In addition to the low cost and superior image quality of the digital system, there is also the added convenience of real-time image viewing through the swivel LCD of the digital camera, wide flexibility of gel sizes, accurate automatic focusing, variable image resolution, and consistent ease of use and quality. Images can be directly imported to a computer by using the USB port on the digital camera, further enhancing the potential of the digital system for documentation, analysis, and archiving. The system is appropriate for use as a start-up gel documentation system and for routine gel analysis.
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Keywords: Digital camera; Electrophoresis; Gel imaging; Gel documentation

1. Introduction

Numerous molecular biology applications rely on the capture of images for the analysis of nucleic acids or proteins. Using electrophoresis techniques, nucleic acids or proteins are separated on agarose or polyacrylamide gels. Subsequently, the gels are stained, e.g. ethidium bromide, and the image is captured on film or in digital format. Although there has been development in electrophoresis and staining methodologies to improve resolution and

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Table 1
Components used for the conversion of the Polaroid MD-4 to a digital gel documentation system

Gel documentation components	Cost
Digital camera components	
MD-4 Polaroid land camera and stand	Pre-existing
Nikon digital camera, Coolpix 5700	413.99
Lens barrel adapter set (52 mm)	15.00
52 mm multicoated UV protective filter	19.00 (optional)
52 mm orange infrared filter 099	44.95
16′ USB 2.0 active extension cable (2)	52.00 (optional)
USB cable (UC-E1)	Included with camera
Nikon A/V cable	Included with camera
Sakar AC adapter (8.4 V)	39.99 (optional)
Plexiglass — for camera holder	
UV transilluminator	Pre-existing
Software components	
NikonView 5	Included with camera
Computer-Windows operating system	Pre-existing
Total cost	558.93

sensitivity, dramatic progress in image capture and analysis has occurred with advances in digital technology. The new digital documentation technology incorporates a CCD video camera, computer, and software for the capture and analysis of digital images, however, these documentation systems are often more sophisticated and expensive than needed for routine gel documentation.

Prior to the development of digital gel documentation technology, film cameras using high speed instant film were widely used for image capture. The common Polaroid land cameras use high speed, ISO 3000, film to capture black and white, 8.5×10.8 cm images. The high speed film provides elevated sensitivity for capturing faint banding patterns and allows for use of small apertures which confer greater depth of field. Although image quality and resolution are high with these systems, each exposure costs approximately one dollar and multiple exposures are often needed to optimize image quality. In addition, the print must be scanned in order to generate a digital image. The proliferation of high quality, consumer grade digital cameras provides a ready source of low-cost cameras for use in gel documentation. Using consumer grade web-cams [1,2], and digital cameras [3,4], effective and inexpensive documentation systems and capture software [3] have been developed. In this communication, a simple protocol is presented for the conversion of the MD-4 Polaroid camera to a digital documentation system.

2. Materials and methods

Components were purchased for the assembly of the digital camera on the existing MD-4 Polaroid stand (Table 1). Assembly began with removal of the Polaroid MD-4 viewfinder/film holder and the camera lens from the copy stand, exposing the bellows of the camera (Fig. 1A–B). A camera holder was constructed from a 6 mm piece of plexiglass cut to the dimensions of the upper bellows frame: 148×148 mm. A 59 mm diameter hole was then cut in middle of the plexiglass holder to fit the camera lens and lens barrel adapter. Four 3 mm holes were drilled in the upper bellows frame, and four matching holes were drilled in the plexiglass camera holder (Fig. 1C). The plexiglass camera holder was then fixed to the upper bellows frame using 3 mm

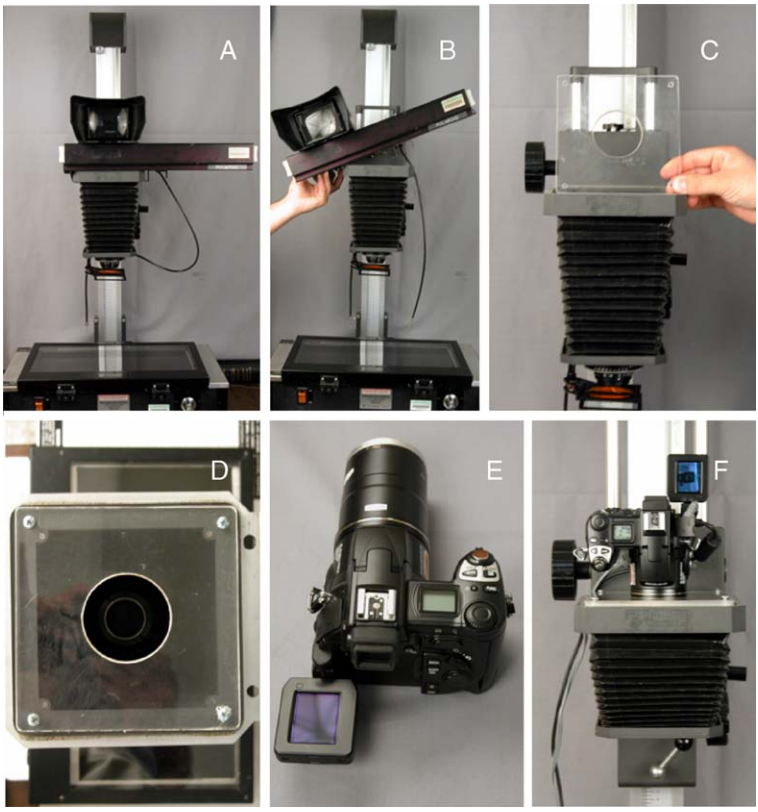

Fig. 1. Assembly of gel documentation system. (A) Polaroid MD-4 instant camera and stand; (B) Removal of the viewfinder/film holder; (C) Finished plexiglass digital camera holder; (D) Plexiglass holder attached to bellows frame; (E) Digital camera with adapters and filters attached; (F) Complete digital gel documentation system with USB and power cables attached.

screws (Fig. 1D). The A/V cable, USB active extension cable, AC adapter, lens barrel adapter, UV filter, and orange filter were attached to the camera and the camera was lowered into the camera holder and bellows (Fig. 1E–F). The camera was switched to black and white image capture mode and the internal flash was turned off. The swivel LCD was adjusted for direct viewing of the gel image for focusing and gel adjustment within the exposure window. A computer with the Windows 98 operating system, located in an adjoining office, was connected to the camera using the USB UC-E1 cable provided with the camera and two 4.8 m active extension cables. The Nikon 5 image grabbing software (provided with the camera) was installed on the computer for image capture.

The images captured using the original Polaroid MD-4 camera and Polaroid 667 instant film were compared to the images generated from the converted digital gel documentation system using a Nikon Coolpix 5700. To test sensitivity and resolution of the two systems, different amounts (50, 100, 250, 500 ng, and 1 μg) of 1 kb ladder DNA (Promega Corporation, Madison, WI) were separated on a 1% agarose gel using electrophoresis (90 V, 1.5 h) and stained with ethidium bromide. The same gel was captured in both film and digital formats using the optimized focus, aperture, and shutter speeds for each system. The instant photographic image was taken at F16 with a 1 s exposure and was scanned at maximum resolution. The digital image

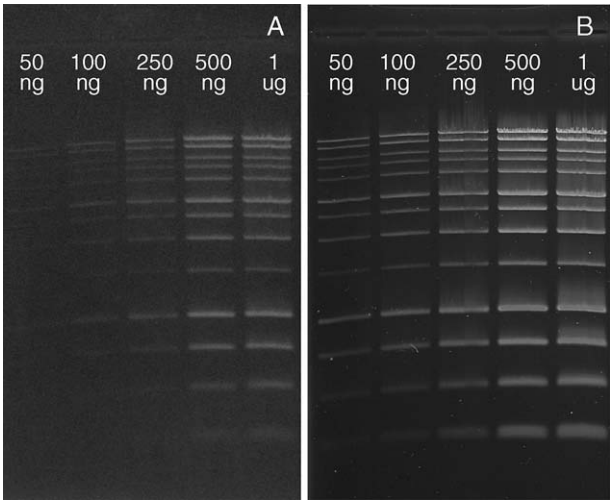

Fig. 2. Comparison of the 1 kb ladder (Promega) using instant film (A) and digital (B) documentation systems. The ladder was separated on a 1% agarose gel using electrophoresis (90 V, 1.5 h) and stained with ethidium bromide.

was captured at F7.3 with an 8 s exposure at 5 megapixel image size in the normal resolution mode.

3. Results and discussion

This study provides a design for the rapid and inexpensive conversion of the widely used MD-4 Polaroid land camera to a high quality digital gel documentation system. We found that the digital system produced images of superior quality and sensitivity as compared to images captured on instant film (Fig. 2). Due to limitations with each camera system, it was not possible to capture the images at the same aperture and shutter speed. However, smaller apertures confer greater resolution and depth of field, thus the Polaroid system was at an advantage in this comparison. In addition, the digital system offers instant review and the option to delete captured images, real-time imaging for adjustment of the gel within the exposure window using the LCD of the camera, variable image resolution, and flexibility in gel size capture through the optical zoom without the need to adjust camera height. The digital system can also be converted back to an instant film camera as needed. The system can be modified to accommodate a wide range of digital cameras through variation in the size of the plexiglass camera holder. The cost of the conversion depends largely on the cost of the digital camera. While a variety of digital cameras can be used, we selected the Nikon Coolpix 5700 because of its image quality, optical zoom, swivel LCD display, RAW image capture mode, manual focus mode, and moderate price (Table 1). We determined that the gel documentation could be converted for as little as $260, given the purchase of an inexpensive ($200) digital camera.

This digital conversion has wide applicability to a broad range of instant film systems because all that is essentially required is a sturdy and adjustable stand for the camera, the digital camera and components, and a computer. Replacement of the UV transilluminator with a white light box will allow the system to capture Westerns, autoradiographs, and SDS-PAGE protein gels. The orange infrared filter can be easily replaced to allow the capture of images using other nucleic acid stains. If a dark room is not available, the camera stand can be fitted with heavy black cloth

to form a hood around the bellows and the UV transilluminator. In addition, printers are available with card readers allowing images to be directly printed from the memory card. This system provides a cost effective means to create a digital archive of images and eliminates many of the problems encountered with upgrading computer systems used to operate expensive gel documentation systems.

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Mention of trade names or commercial products in this article is solely for the purpose of providing specific information and does not imply recommendation or endorsement by the U.S. Department of Agriculture.

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